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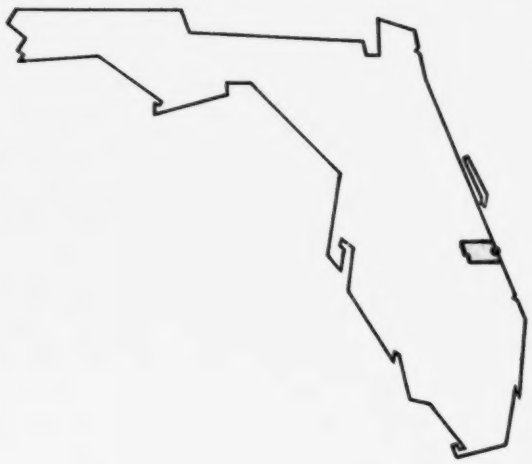
FLOOD INSURANCE STUDY

WAVE HEIGHT ANALYSIS



TOWN OF INDIAN RIVER SHORES, FLORIDA
INDIAN RIVER COUNTY

MARCH 30, 1982

Federal Emergency Management Agency

COMMUNITY NUMBER-120121

ANALYSIS OF WAVE HEIGHTS
FOR
TOWN OF INDIAN RIVER SHORES, INDIAN RIVER COUNTY, FLORIDA

FEDERAL EMERGENCY MANAGEMENT AGENCY

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1.0 INTRODUCTION

1.1 Background and Purpose

The Federal Emergency Management Agency recently adopted recommendations by the National Academy of Sciences to include prediction of wave heights in Flood Insurance Studies for coastal communities subject to storm surge flooding, and to report the estimated wave crest elevations as the base flood elevations on Flood Insurance Rate Maps (FIRMs).

Previously, FIRMs were produced showing only the stillwater storm-surge elevations due to the lack of a suitable and generally applicable methodology for estimating the wave crest elevations associated with storm surges. These stillwater elevations were subsequently stipulated in community flood plain management ordinances as the minimum elevation of the first floor of new construction. Communities and individuals had to consider the additional hazards of velocity waters and wave action on an ad hoc basis. Because there has been a pronounced tendency for buildings to be constructed only to meet minimum standards, without consideration of the additional hazard due to wave height, increasing numbers of people could unknowingly be accepting a high degree of flood-related personal and property risk in coastal areas subject to wave action. Therefore, the Federal Emergency Management Agency has pursued the development of a suitable methodology for estimating the wave crest elevations associated with storm surges. The recent development of such a methodology by the National Academy of Sciences (Reference 1) has led to the adoption of wave crest elevations for use as the base flood elevations in coastal communities.

The Town of Indian River Shores, Florida, is located on the open coast and is subject to flooding from tidal surges associated with hurricanes.

Flooding has been caused by several hurricanes in and around Indian River County. Among the more severe were the storms of July-August 1926, August 1928, September 1928, and August-September 1964. The hurricane of September 1928 is considered one of the most violent ever to strike Florida. High water and wave damage was reported along the entire length of Indian River. The center of Hurricane Cleo (August-September 1964) passed through Indian River County in a north-northwesterly direction almost parallel to the Florida coast.

The purpose of this study is to revise the FIRM for Indian River Shores to include the effects of wave action associated with flooding from the Atlantic Ocean at the open coast and at Indian River.

2.0 INVESTIGATIONS

2.1 Previous Studies

Stillwater elevations for hurricane surges with 10-, 50-, 100-, and 500-year return periods were determined by the National Oceanic and Atmospheric Adminis-

tration (NOAA) for the open coast of Indian River County. The 100-year stillwater elevations were used as base flood elevations for the previous Flood Insurance Study (Reference 2) and for the FIRM that is currently in effect for Indian River Shores (Reference 3).

The NOAA storm-surge elevations were determined using a computer simulation model of hurricane forces (References 4 and 5). Weather records were analyzed to determine probable atmospheric pressure drop, radius of maximum winds, and forward speed and direction of storms occurring near the study area. Using these data, in conjunction with the astronomical tides and bathymetric data, stillwater elevations for various probabilities were calculated. Results of these calculations were calibrated against tide gage records and high-water marks for historical events at various locations along the coast.

Tidal backwater elevations for Indian River were determined by NOAA, using the above data in conjunction with subjective judgment regarding terrain and depth.

The stillwater elevations developed for these previous studies were used as the starting elevations for the wave height analysis presented herein.

This report is authoritative for the purposes of the National Flood Insurance Program, and data presented herein supersede all previous flood elevation determinations.

2.2 Data Collection and Review

All available source data applicable for the wave height analysis were collected and reviewed. Because wave height calculations are based on such parameters as the size and density of vegetation, natural barriers (sand dunes), buildings, and other manmade structures, it was necessary to obtain detailed information on the physical and cultural features of the study area.

Officials of the Town of Indian River Shores and Indian River County were contacted for maps and other possible data sources to be used in the analysis. In addition, the Florida Department of Natural Resources, Bureau of Beaches and Shores; the Florida Department of Transportation; the U.S. Army Corps of Engineers, Jacksonville District; and the National Ocean Survey were contacted and all applicable data sources were obtained.

The principal source materials used for the wave height analysis are listed below.

a. Topographic data (ground elevations, seawall elevations, and locations of physical features) were determined using U.S. Geological Survey topographic maps at a scale of 1:24,000, with a contour interval of 5 feet (Reference 6); Lloyd and Associates topographic maps at scales of 1:1,200 and 1:2,400, with contour intervals of 1 and 2 feet (References 7, 8, 9, and 10); National Ocean Survey storm evacuation maps at a scale of 1:62,500, with a contour interval of 5 feet and spot elevations along roads (Reference 11); and Florida Department

of Natural Resources beach profiles at a scale of 1:600 (Reference 12) and topographic maps of the immediate Atlantic coastline at a scale of 1:1,200, with a contour interval of 2 feet (Reference 13).

b. Recent stereoscopic aerial photography at a scale of 1:12,000 was used to determine vegetation and building parameters and to supplement the topographic maps for locations of physical features (References 14 and 15).

2.3 Wave Height Analysis

The methodology for analyzing the effects of wave heights associated with coastal storm surge flooding is described in the National Academy of Sciences report (Reference 1). This method is based on the following major concepts. First, depth-limited waves in shallow water reach a maximum breaking height that is equal to 0.78 times the stillwater depth. The wave crest is 70 percent of the total wave height above the stillwater level. The second major concept is that wave height may be diminished by dissipation of energy due to the presence of obstructions, such as sand dunes, dikes and seawalls, buildings, and vegetation. The amount of energy dissipation is a function of the physical characteristics of the obstruction and is determined by procedures prescribed in Reference 1. The third major concept is that wave height can be regenerated in open fetch areas due to the transfer of wind energy to the water. This added energy is related to fetch length and depth.

Wave heights were computed along transects (cross section lines) in accordance with the Users Manual for Wave Height Analysis (Reference 16). The transects were located along the coastline as shown in Figure 1. They were located with consideration given to the physical and cultural characteristics of the land so that they would closely represent conditions in their locality. Transects were spaced close together in areas of complex topography and dense development. In areas having more uniform characteristics, they were spaced at larger intervals. It was also necessary to locate transects in areas where unique flooding existed and in areas where computed wave heights varied significantly between adjacent transects.

Each transect was taken perpendicular to the shoreline and extended to the inland limit of tidal flooding. Along each transect, wave heights and elevations were computed considering the combined effects of changes in ground elevation, vegetation, and physical features. The stillwater elevations for the 100-year flood were used as the starting elevations for these computations. Wave heights were calculated to the nearest 0.1 foot, and wave elevations were determined at whole-foot increments along the transects. The location of the 3-foot breaking wave for determining the terminus of the V Zone (area with velocity wave action) was also computed at each transect. Table 1 provides a listing of the transect locations and stillwater elevations, as well as maximum wave crest elevations in Indian River Shores.

Figure 2 is a profile for a typical transect illustrating the effects of energy dissipation and regeneration on a wave as it moves inland. This figure shows the wave elevations being decreased by obstructions, such as buildings, vegeta-

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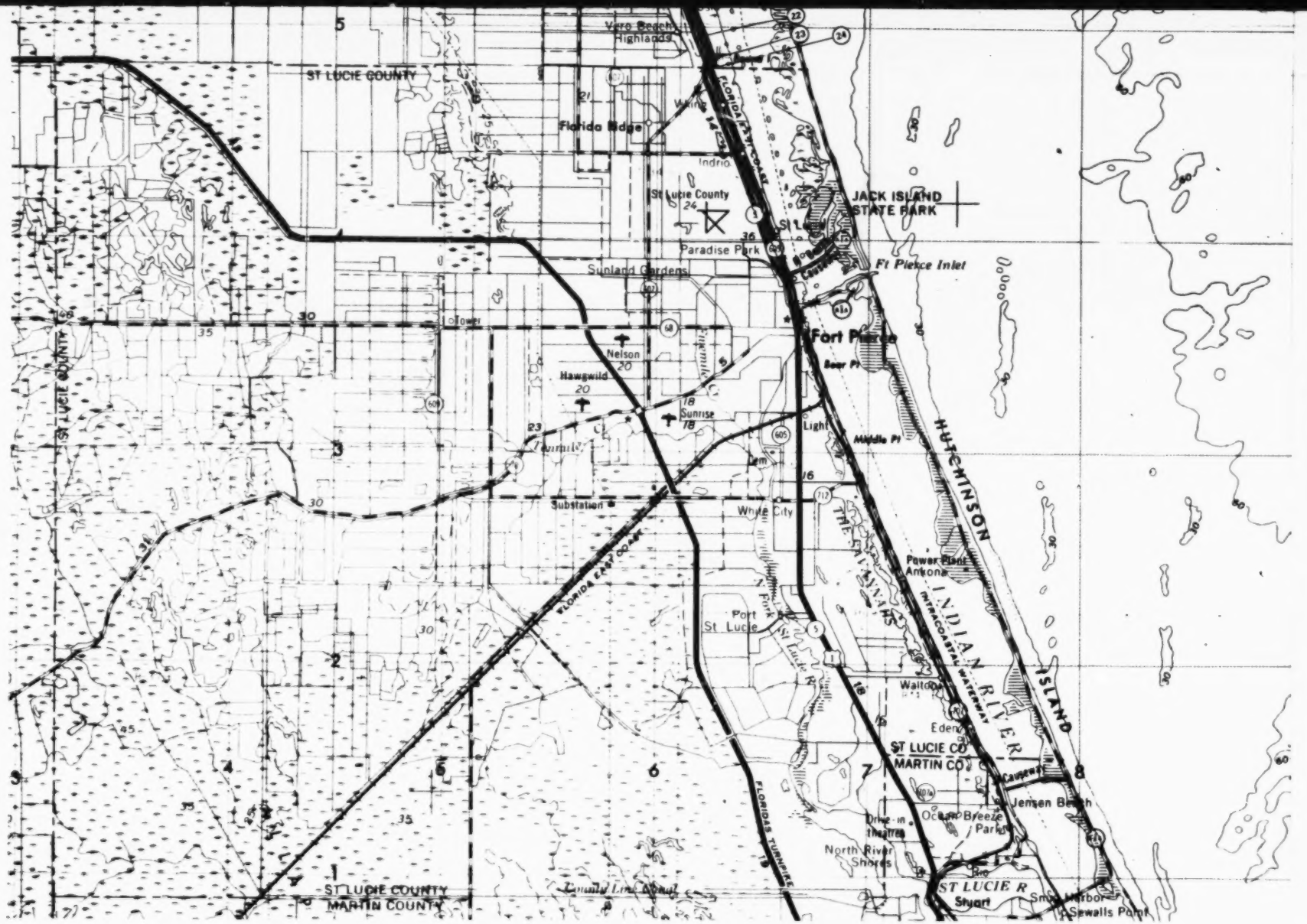

FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

INDIAN RIVER COUNTY, FL

APPROXIMATE SCALE

2000 0 2000 4000 6000 FEET

TRANSECT LOCATION MAP

Table 1.
Transect Locations, Stillwater Elevations, and Maximum Wave Crest Elevations

Transect	Location	Elevation (Feet NGVD) Stillwater	Wave Crest
13	Indian River County - From east side of Indian River westward to the limit of inundation by the 100-year storm surge; crosses east end of Martha Lane	6.0[1]	7[1]
14	Indian River Shores/Indian River County - From the Atlantic coastline westward to the limit of inundation by the 100-year storm surge; crosses Luther Road at intersection with road to Copelands Landing in Indian River County	8.0[2]	12[2]
15	Indian River Shores/Indian River County - From the Atlantic coastline westward across Indian River to the limit of inundation by the 100-year storm surge; crosses State Highway AlA approximately 1600 feet south of intersection with Johns Island Drive in Indian River Shores	8.0[2]	12[2]
16	Indian River Shores/Indian River County - From the Atlantic coastline westward across Indian River, through Gifford Island to the limit of inundation by the 100-year storm surge; crosses State Highway AlA in Indian River Shores approximately 2700 feet south of intersection with Fred R. Tuerk Road	8.0[2]	12[2]
17	Vero Beach/Indian River County - From the Atlantic coastline westward across Indian River to the limit of inundation by the 100-year storm surge; crosses Bethel Creek Drive in Vero Beach approximately 250 feet south of intersection with El Perdido Street	8.0[2]	12[2]

[1]Indian River
[2]Atlantic Ocean

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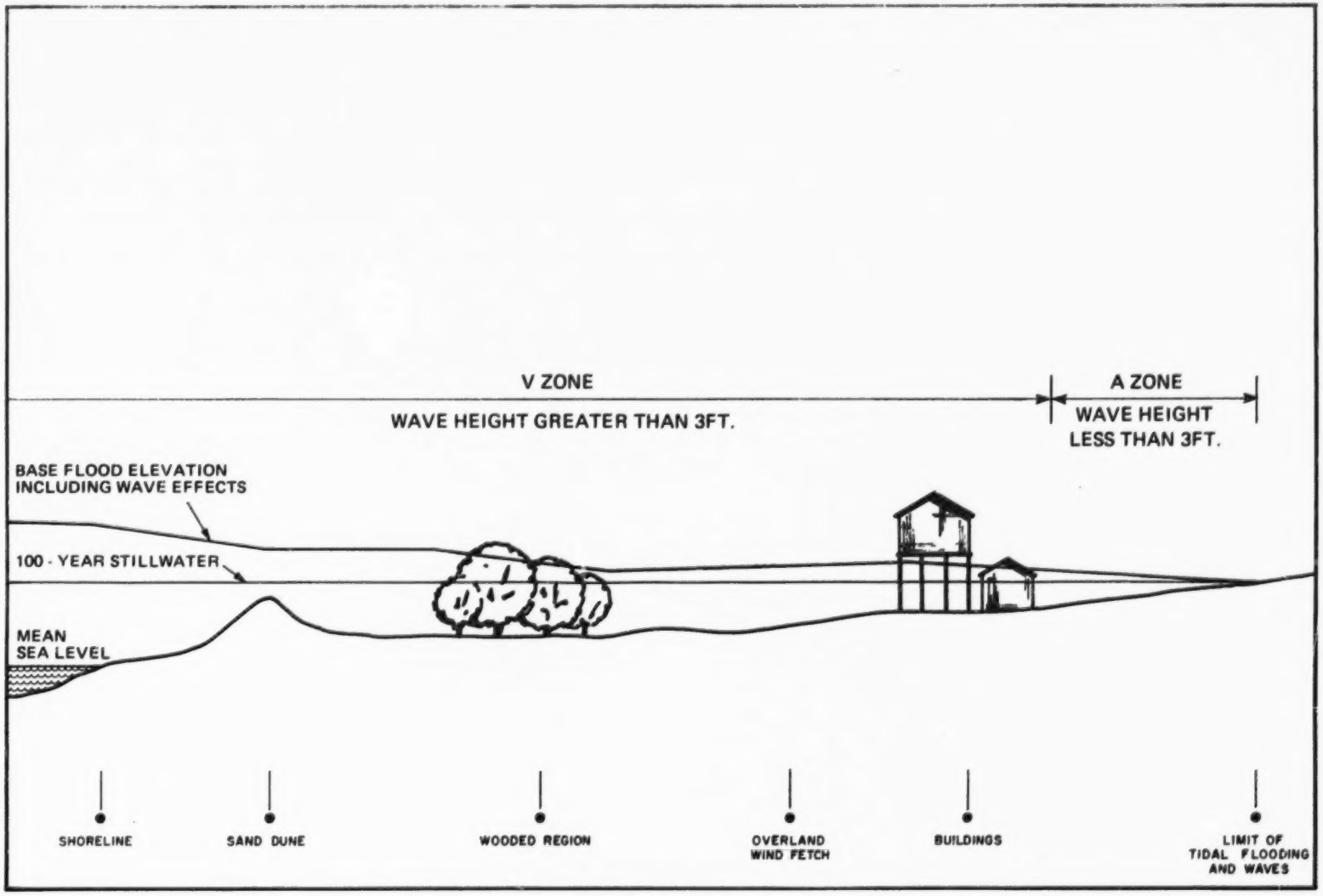

FIGURE 2
TYPICAL TRANSECT SCHEMATIC

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tion, and rising ground elevations, and being increased by open, unobstructed wind fetches. Actual wave conditions in Indian River Shores may not necessarily include all the situations illustrated in Figure 2.

After analyzing wave heights along each transect, wave elevations were interpolated between transects. Various source data were used in the interpolation, including topographic maps (References 6 through 11), beach profiles (Reference 12), and aerial photographs (References 14 and 15), along with engineering judgment. Controlling features affecting the elevations were identified and considered in relation to their positions at a particular transect and their variation between transects.

2.4 Results

Wave heights of approximately 6 feet, with wave crest elevations of 12 feet, will be encountered at the Atlantic Ocean open coast shoreline during a 100-year storm tide. These waves are completely dissipated, and the 100-year storm surge is stopped at the seaward toe of the primary coastal dune by rising ground elevations. No shore protection structures are located within the 100-year Atlantic coastal flood plain in Indian River Shores.

From the northern corporate limits of Indian River Shores to Johns Island, wave heights of approximately 2 feet, with wave crest elevations of 7 feet, are generated across Indian River. High ground elevations and vegetation on Gem Island completely dissipate the 1 foot wave, however, the wave is quickly regenerated to the west of the island over Indian River. South of Johns Island to the southern corporate limits, wave heights of from 1 to 2 feet, with wave crest elevations of 6 feet are generated. These waves are dissipated primarily outside the corporate limits of Indian River Shores on the western shore of Indian River by a combination of rising ground elevations and obstructions in the flood plain such as buildings and vegetation.

3.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

A prime purpose of the National Flood Insurance Program is to encourage local governments to adopt sound flood plain management programs designed to reduce future flood losses. The FIRM for Indian River Shores has been revised to incorporate the latest available information, including wave height data, to assist the community in developing the most appropriate and effective flood plain management measures.

3.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the Federal Emergency Management Agency as the base flood for purposes of flood plain management. This flood has a 1 percent chance of being equalled or exceeded each year and is expected to be exceeded once on the average during any 100-year period. The risk of

having a flood of this magnitude or greater increases when periods longer than 1 year are considered. For example, over a 30-year period, there is a 26 percent chance of experiencing a flood equal to or greater than the 100-year flood. The 500-year flood plain is also shown on the FIRM to indicate areas of moderate flood hazards.

Areas inundated by the 100-year flood are shown as A and V Zones on the community's FIRM. It is in these areas that the Federal Emergency Management Agency requires local communities to exercise flood plain management measures as a condition for participation in the National Flood Insurance Program.

3.2 Base Flood Elevations

Areas within the community studied by detailed engineering methods have base flood elevations established in A and V Zones. These are the elevations of the base (100-year) flood relative to the National Geodetic Vertical Datum of 1929. In coastal areas affected by wave action, base flood elevations are generally maximum at the open coast shoreline. These elevations generally decrease in a landward direction at a rate dependent on the presence of obstructions capable of dissipating the wave energy. Where possible, changes in base flood elevations have been shown in 1-foot increments on the FIRM. However, where the scale did not permit, 2- or 3-foot increments were sometimes used. Base flood elevations shown in the wave action areas represent the average elevation within the zone. Current program regulations generally require that all new construction be elevated such that the first floor, including basement, is above the base flood elevation in A and V Zones.

3.3 Velocity Zones

The U.S. Army Corps of Engineers (Reference 17) has established the 3-foot breaking wave as the criterion for identifying coastal high hazard zones. This was based on a study of wave action effects on structures. This criterion has been adopted by the Federal Emergency Management Agency for the determination of V Zones. Because of the additional hazards associated with high-energy waves, the National Flood Insurance Program regulations require much more stringent flood plain management measures in these areas, such as elevating structures on piles or piers. In addition, insurance rates in V Zones are higher than those in A Zones with similar numerical designations.

The location of the V Zone is determined by the 3-foot breaking wave as discussed previously. The detailed analysis of wave heights performed in this study allowed a much more accurate location of the V Zone to be established. The V Zone generally extends inland to the point where the 100-year flood depth is insufficient to support a 3-foot breaking wave.

4.0 INSURANCE APPLICATION

The assignment of proper actuarial insurance rates requires that frequency and depth of flooding be estimated as accurately as possible. Because waves can add considerably to expected flood depths, it is important that insurance

rates consider this additional hazard. The Federal Emergency Management Agency has developed a process to transform the data from this study into flood insurance criteria. This process includes the determination of Flood Hazard Factors and the designation of flood insurance zones.

4.1 Flood Hazard Factors

The Flood Hazard Factor (FHF) is the device used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their FHF are used to set actuarial insurance premium rate tables.

The FHF is shown as a three-digit code that expresses the difference between the 10- and 100-year flood elevations to the nearest 0.5 foot. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year water-surface elevations is greater than 10.0 feet, the FHF is computed to the nearest foot.

4.2 Flood Insurance Zones

After wave elevations for the 100-year storm surge were determined and mapped, the study areas were divided into zones, each having a specific flood potential and FHF. Each zone was assigned one of the following flood insurance zone designations:

Zone V12:	Special Flood Hazard Areas inundated by the 100-year flood, and that have additional hazards due to velocity (wave action); base flood elevations shown, and zones subdivided according to FHFs.
Zones A9 and A10:	Special Flood Hazard Areas inundated by the 100-year flood, with base flood elevations determined and zone designations assigned according to the FHFs.
Zone B:	Areas between the Special Flood Hazard Areas and the limits of the 500-year flood plain, including areas that are protected from the 100- and 500-year floods by dike, levee, or other water control structure; and areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot, or where the contributing drainage area is less than 1 square mile. Zone B is not subdivided.

Zone C: Areas not subject to flooding by the 500-year flood. Zone C is not subdivided.

Table 2, "Flood Insurance Zone Data," summarizes the FHFs, flood insurance zones, and base flood elevations for each flooding source in the study area.

4.3 Flood Insurance Rate Map

After flood insurance zones were established for the study area, the FIRM for Indian River Shores was revised to incorporate the new zone information. This map (Exhibit 1) contains the official delineation of flood insurance zones and base flood elevations.

In preparing the revised FIRM, updated topographic information was used to revise the Atlantic Ocean shoreline and some zone boundaries in areas not affected by the wave height analysis. Corporate limits and cultural features were revised using a current community map (Reference 18).

5.0 OTHER STUDIES

FIRMs for the incorporated community of Vero Beach and unincorporated areas of Indian River County are being revised concurrently with Indian River Shores to include wave height analysis. These revised studies will be in agreement with this study.

6.0 REFERENCES

1. National Academy of Sciences, Methodology for Calculating Wave Action Effects Associated With Storm Surges, 1977

2. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Insurance Study, Town of Indian River Shores, Florida, September 5, 1979

3. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Insurance Rate Map, Town of Indian River Shores, Florida, Scale 1:12,000, September 5, 1979

4. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Technical Memorandum NWS TDL 52, SPLASH (Special Program to List Amplitudes of Surges from Hurricanes): Part I, Landfall Storms, C.P. Jelesnianski, 1972

5. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Technical Memorandum NWS TDL 52, SPLASH; Part II, General Track and Variant Storm Conditions, C.P. Jelesnianski, 1974

Table 2. Flood Insurance Zone Data

Flooding Source	Stillwater Elevation 10-Year	50-Year	100-Year	500-Year	FHF	Zone	Base Flood Elevation (Feet NGVD)*
Atlantic Ocean							
Open Coast	4.2	6.8	8.0	10.4	060	V12	10 to 12
					050	A10	8 to 10
Indian River							
Northern Corporate Limits to Johns Island	2.2	4.8	6.0	8.4	045	A9	6,7
South of Johns Island	1.2	3.8	5.0	7.4	045	A9	5,6

*Due to map scale limitations, base flood elevations shown on the FIRM may represent average elevations for the zones depicted.

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6. U.S. Department of the Interior, Geological Survey, 7.5-Minute Series Topographic Maps, Scale 1:24,000, Contour Interval 5 feet: Vero Beach, Florida (1949), Photorevised (1970); Riomar, Florida (1948), Photorevised (1970)

7. Lloyd and Associates, Vero Beach, Florida, Topographic Map, Phase 2, John's Island, Scale 1:1,200, Contour Interval 2 feet, September 1969

8. Lloyd and Associates, Vero Beach, Florida, Topographic Map, John's Island 3rd Phase, Scale 1:1,200, Contour Interval 1 foot, 1970

9. Lloyd and Associates, Vero Beach, Florida, Topographic Map, the Island of John's Island, Scale 1:2,400, Contour Interval 1 foot, May 21, 1974

10. Lloyd and Associates, Vero Beach, Florida, Topographical Map of Gem Island, Scale 1:1,200, Contour Interval 1 foot, May 15, 1974

11. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Survey, Storm Evacuation Maps, T-15085 and T-15086, Scale 1:62,500, Contour Interval 5 feet Supplemented With Spot Elevations on Roads, Palm Bay, Florida (1978), Fort Pierce, Florida (1978)

12. Florida Department of Natural Resources, Bureau of Beaches and Shores, Indian River County Beach Profiles, Scale 1:600, November 1972

13. Florida Department of Natural Resources, Bureau of Beaches and Shores, Indian River County, Coastal Construction Control Line Phototopographic Maps Preliminary, Scale 1:1,200, Contour Interval 2 feet, Photographed December 6, 1978

14. Florida Department of Transportation, Stereoscopic Aerial Photographs of Indian River County, Florida, Scale 1:12,000, December 6, 1978

15. Federal Emergency Management Agency, Stereoscopic Aerial Photographs of Indian River County, Florida, Scale 1:12,000, March 6 and May 5, 1981

16. Federal Emergency Management Agency, Users Manual for Wave Height Analysis, Revised February 1981

17. U.S. Department of the Army, Corps of Engineers, Galveston District, Guidelines for Identifying Coastal High Hazard Zones, June 1975

18. Town of Indian River Shores, Florida, Town of Indian River Shores, Florida, Scale 1:4,800, October 16, 1980